

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING**



**Senior Design & Professionalism II
ELEG 442-P01 Spring 2020**

**Intelligent Sensing and Alert System for Bicycle Accident
Reductions (RISAF)**

Final Project Report

Team Number 4:
Timothy Shields
Precious Effiong
Adedapo Adetayo
Simplice Kamwa (T.L)

**Instructors: Professor Turner & Professor Musa
Project Facilitator: Dr. Qian**

Date of Submission: 04/17/2020

Project Executive Summary

Team Mission Statement

Our mission is to design an intelligent sensing and alarm system to aid in reducing bicycle accidents.

Having this system in place will help assure bicycle riders that they can ride more safely while increasing motorists awareness of nearby cyclists.

Problem Statement

Over the years, there has been a high volume of bicycle accidents in downtown areas of major cities. In 2015, 45,000 pedal cyclists were injured and 818 pedal cyclists killed in motor vehicle traffic crashes in the country.

Proposed Deliverables

- ❖ The embedded system will consist of a Jetson Nvidia TX2 microcontroller, camera and motion sensor. The TX2 will serve as a communication interface for the camera and sensors.
- ❖ The phone mobile application will be designed in Android Studio using the Java programming language. The application will allow the rider to be alerted through sound or vibration.
- ❖ Our road lane light-emitting diodes(LEDs) will be installed on the road between the car and bicycle lanes. They will blink only when the system detects a moving object within the range of 80 feet.

Budget

Our project budget was \$600 and the amount spent was \$550.

Customer Requirements & Engineering Solutions

- ❖ The embedded system should fit on an electrical pole at a road intersection.
- ❖ Road lane lights should be weather adaptable.
- ❖ Road lane lights should be visible.
- ❖ The mobile application should be user-friendly.
- ❖ Device alerts should not be distracting.
- ❖ The motion sensor should detect moving objects within range.

Major Constraints

- ❖ Not all roads have bike lanes for road lane lights.
- ❖ Not all bike riders use their mobile device while riding.
- ❖ The system cannot detect potential dangers if automobiles or trucks are not within the operating range.

Benefits

- ❖ **Environmental:** Bicycling and walking annually can displace between 1.2% and 5% of passenger vehicle emissions of Carbon Monoxide, Nitrogen Oxides, and Carbon Dioxide.
- ❖ **Economical:** Our project helps to reduce costs from building car parking lots to owning a car. People who ride bicycles save money on vehicular transportation upkeep, and have lower travel costs on average.
- ❖ **Health & Safety:** The health impacts of cycling span mental, physical and psychological well-being. The aim of this project is to reduce these fatality rates through the implementation of our proposed safety infrastructure.
- ❖ **Social:** Bicycle safety impacts the fabric of a community and encourages for healthy cycling culture amongst road users.
- ❖ **Technical:** 70% of nighttime collisions are due to inadequate visibility. The implementation of our proposed safety infrastructure. can greatly improve bicycle safety.

Recommendation

- ❖ The intelligent embedded system will be programmed using the Jetson SDK manager
- ❖ A machine learning model will be used when programming the camera to ensure the accuracy of the readings and alerts received.
- ❖ It is a system that can be installed for multiple roadways and easily adaptable to fit different road configurations.
- ❖ Additional features can be configured with more specifications for the system.

Conclusion

The implementation of our system will greatly impact the safety culture amongst both bicycle riders and car drivers. By completing this project, we will have established a proof of concept that an intelligent system in place can accomplish our objectives. We will gain a better understanding of how to integrate systems to communicate and take action based on predefined configurations.

List of Figures

1.1: Fatalities Rate from 2013-2017.....	12
2.3: Gantt Chart.....	23
5.1: Jetson TX2 Microcontroller Front Device.....	33
5.2: Depiction of road intersection with vehicles.....	33
5.3: Jenson TX2 Directory Code.....	35
5.4: Code snippet showing the enable/disable bluetooth function.....	37

List of Tables

5.1: Equipment List.....	32
5.5: Product Comparison.....	39

List of Team Members & Roles

Simplice Kamwa.....	Team Lead & Embedded System Developer
Precious Effiong.....	Secretary & Mobile Application Developer
Adedapo Adetayo.....	Data Analyst & Embedded System Developer
Timothy Shields.....	Presentation Manager & Mobile Application Developer

Section 1 - Project Scope

1.1 Problem Statement

Over the years there has been a high volume of bicycle accidents in downtown areas of major cities such as New York, San Francisco, Seattle and San Jose in America. In 2015, 45,000 pedal cyclists were injured and 818 pedal cyclists killed in motor vehicle traffic crashes in the country. Many people wish to adopt cycling as their main mode of transportation but there are a lot of fear factors that impede this. Current safety options are available but may not be suitable for every demographic or cost-effective on the user hence the need for a product that works for both stakeholders, the motor driver and cyclist. The goal of this project is to design an intelligent sensing and alarm system to aid in reducing bicycle accidents. Having this system in place will be very beneficial to bicycle riders knowing that they can ride more safely while increasing motorists' awareness of nearby cyclists. It will also potentially generate revenue for the government from the installation of the embedded systems for roads across these major cities nationwide.

1.2 Client Identification and Recognition of Need

It is shown in recent studies that fatal bicycle accidents are on the rise. In 2017, there were 783 bicyclists killed in crashes with motor vehicles in the United States. The vast majority of these accidents are due to the lack of awareness. In some car accident crashes, it has been determined that the car drivers were not aware of a bicycle presence nearby. In other cases, it was determined that the bicycle riders were not aware of the presence of a car in the nearby lane. Pedestrian and bicyclist fatalities increased by 32% in the ten-year period between 2008 and 2017. During that same time period, total traffic fatalities decreased by 0.8 %, according to a report from National Highway Traffic Safety Administration. These numbers show that the need of increasing awareness on our road is essential. The goal of this project is to design and implement an intelligent sensing and alarm system for bicycle accidents reduction.

1.3 Project Goals and Needs

Goal: The goal of this project is to design an intelligent sensing and alarm system to aid in reducing bicycle accidents. Having this system in place will assure cyclists that they can ride more safely while increasing motorists awareness of nearby cyclists. It can potentially generate revenue for the government from the installation of the embedded systems for roads across these major cities nationwide.

Objective: This project will help bicycle riders stay safe and alert them of potential dangers on the road. The bicycle rider will be alerted through our pathway light-emitting diode(LED) lighting and the use of an android application that is programmed with Java. We will only focus on the Android platform and future work may include development for iOS platform on iPhone devices. If the user opts to not download the mobile app or does not possess an Android device, the pathway LED lighting will still be available to alert the bike rider and the approaching vehicle. The pathway LED lighting will receive signals from our microcontroller, which is used to capture data from thermal and motion sensors.

Customer Requirement: Our team is required to design an intelligent sensing and alarm system with detailed configurations. For the embedded system, it is important that it is housed in a safe compartment on an electric pole that overlooks the intersection to capture traffic. This ensures that the readings from the sensor are accurate and not impacted by different conditions. The system should be able to collect several types of data such as video, sound, light, and movement under various scenarios. Our system must be a machine learning model offline to identify cyclists or other moving relevant objects using the collected data. The system must be tested on the model after training to ensure identification of objects in real time and sound alarm when necessary. We have also taken into consideration the luminosity of the road lane LEDs which is important to ensure adequate visibility during the day and night. The mobile application should not be a distraction but aid to enhance the functionality of the system. As a whole, the system should work seamlessly through integrated communication between the various components.

1.4 Contemporary Issues

For many years, bicycles have been a source of enjoyment and exercise for many people around the world. Bikes have also been used to move from point A to point B such as commuting to work, visiting friends, and exploring the surrounding. With our project, the main contemporary issue that we have to deal with is our embedded system. With our embedded system the two main issues we face are security and design limitations.

With our embedded system being the brain of our project if it is hacked or altered in any way it can affect the data received and given to both the mobile application and the road lane lights. If the brain is hacked there will either be incorrect or no information sent to our devices therefore creating a safety concern while our cyclists are on the road.

With our design limitation we have to be mindful of the range in which we can collect data as well as the amount of power that will be needed to power the system. If we receive too much power from the electrical pole and can disrupt the function of the embedded system. Whereas, if we don't receive enough power to the system it can create a power shortage, causing our system not able to run to its full potential. With our project we want to ensure the safety of our cyclists through the use of our system so that we can create a safer, friendly environment for cyclists and motorists.

1.5 Potential Impact of Project on Society

1. Safety

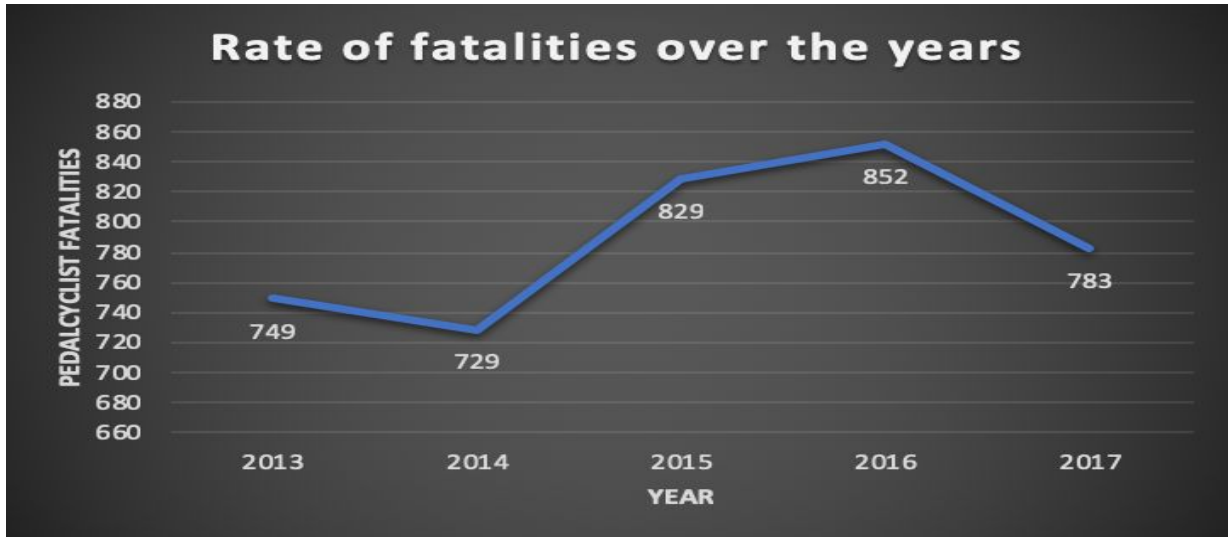


Figure 1.1: Rate Fatalities form 2013-2017 [1]

In 2015, there were 5000 fewer bicycle accidents than the prior year. However, the number of fatal accidents increased by more than 12% percent during this same time. Statistics show that while there has been a general decrease in the rate of bicycle accidents, the rate of fatality of these accidents is on the rise. One major factor that this can be attributed to is while more cities are becoming bicycle-friendly, not all the necessary regulations or infrastructure have been put in place to ensure the safety of cyclists on the roads. Additionally, motorists may not be aware of these bicycle regulations and cyclists may not be aware of safe biking practices. In general, 79% to 97% of drivers feel more comfortable on the road with cyclists when there are protected bike lanes. The impact of our project is to improve the safety of these cyclists through the implementation of our proposed infrastructure as well as the utilization of the mobile application.

1.5 Potential Impact of Project on Society(Continued)

2. Environmental

According to the United States Environmental Protection Agency (EPA), motor vehicles collectively cause 75% of carbon monoxide pollution. The Environmental Defense Fund (EDF) estimates that on-road vehicles cause $\frac{1}{3}$ of the air pollution that produces smog in the U.S., and transportation causes 27% of greenhouse gas emissions. By cycling ten kilometers each way to work would save 1500 kg of greenhouse gas emissions each year. Bicycling and walking annually can displace between 1.2% and 5% of passenger vehicle emissions of carbon monoxide, nitrogen oxides, carbon dioxide. Our project would impact the environment by increasing the likelihood of cycling, because of the safety assurance our project will provide. As a result, our project will decrease air pollution and safeguard the environment by diminishing the emissions of greenhouse gases.

3. Technical

When approaching the technical impact of our project we had to compare our project to other products on the market currently. Nearly 70% of all night-time bicycle-car collisions are due to inadequate visibility. Products such as the Beryl Laser Bike Light and the Revolights, which helps to provide visibility for the cyclist at night but could be ineffective during daylight hours. When considering a majority of the products that pertain to traffic safety, the distinguishing factor of our product is the implementation of our road lane lights that has Light Emitting Diodes (LEDs), which help to provide a means to keep both cyclist and motorist aware of each other during both daylight and nighttime hours.

4. Economic

On average, cycling at least 10 kilometers each way to work each day will save about \$1700 per year in transport costs. For example, one mile of roadway planned through Golden Gate Park is 1,283 times more

1.5 Potential Impact of Project on Society(Continued)

expensive to San Franciscans than 1 mile of a protected bike lane. The family car costs up to 50 cents per kilometer to run. In comparison, the cost of buying and maintaining a bike is only 1% of the cost of buying and maintaining a car. Our project helps to reduce costs from building car parking lots to owning a car. People who ride bikes save money on vehicular transportation upkeep, and have lower travel costs on average which means more money at their disposal.

5. Social

The impact of bicycle safety is important to the fabric of the community not only to build a cycling culture in cities but to encourage camaraderie between cyclists, motorists and other road users. There is an unpronounced but palpable sense of identity cyclists share in their circles as they ride together to work or rally together for bicycle regulations coupled with the ease of being able to stop for a quick chat. This helps to build social capital which means the interactions and networks that build trust among citizens. Bicycle infrastructure can also improve the appearance of a community or city by allowing more space for greenery in place of parking spots and a reduction in air and noise pollution. Strong cycling supported by bicycle safety allows for equality in terms of accessibility to this mode of transport across different ages, social class, gender, and nationality; anyone can adopt cycling. None of this would be possible if people did not feel safe riding their bicycles on the street hence the need to ensure bicycle safety at all times.

6. Health

The health implications of bicycle safety cannot be overemphasized as it goes beyond our physical health; it can impact one's psychological and mental wellbeing. Even though cyclists breathe 2 to 3 times more air than motorists, motorists breathe about 60% more carbon monoxide and significantly more pollutants than cyclists. In addition to satisfying the recommended 30 minutes of daily moderate-intensity physical activity, cycling

1.5 Potential Impact of Project on Society(Continued)

can reduce obesity diabetes by 14% percent and prevent cardiovascular diseases. It is also great for mental stimulation and can improve one's mood and stress levels. Overall, cycling reduces the rate of all-cause mortality by 10% and this shows that with improved bicycle safety on the roads, the health of cyclists can be greatly improved when they are supported in their efforts to stay safe on the roads through the implementation of our infrastructure.

1.6 Initial Project Constraints

1. We are not very familiar with the traffic flow in downtown areas across major cities.
2. Not all roads have bike lanes for pathway lights.
3. Not all bike riders use their mobile device while riding.
4. The system can not detect potential dangers if automobiles or trucks are not within the operating range.

Section 2 - Project Planning and Task

Definition

2.1 Task Identification

Roles were assigned based on group discussions and agreements during our first meeting. Each member of Team 4 is expected to attend every meeting on time and come ready to be engaged in group activities. Each member has a main function specific to the technical aspect of the project as well as an adjunct role that is less technical.

1. Embedded System Developer: Simplice Kamwa (Team Lead)

Adjunct: Accountant

The embedded system developer is responsible for programming the microcontroller to communicate with the camera and motion sensor.

The team leader is responsible for the achievement of team goals. He is responsible for managing task assessments and acts as a liaison for communication between group members, facilitator sponsor and the instructor. The team leader is responsible for calling special meetings as necessary.

The role of the accountant is to manage monetary expenditures and maintain records while adhering to an assigned budget, perform a cost-benefit analysis and communicate with team members to determine which equipment and software are most cost-effective for the project.

2. Mobile Application Developer: Precious Effiong

Adjunct: Secretary

The role of the application developer is to program a mobile application in the Integrated Development Environment to communicate with the embedded system.

The role of the secretary is to schedule meeting times based on team members' availability, prepare meeting agenda, take minutes of every meeting to present at the next meeting, store all necessary physical documents in a binder and all electronic documents in a shared folder in Google Drive.

2.1 Task Identification(Continued)

3. Mobile Application Developer: Timothy Shields

Adjunct: Presentation Manager

The role of the application developer is to program a mobile application in the Integrated Development Environment to communicate with the embedded system.

The role of the presentation manager is to organize, create, design, and maintain all information from the project that is to be in the presentation. The presentation manager is also responsible for the presentation set-up equipment.

4. Embedded System Developer: Adedapo Adetayo

Adjunct: Data Analyst

The embedded system developer is responsible for programming the microcontroller to communicate with the camera and motion sensor.

The role of the data analyst is to set the clearly defined business objectives of the project which will be done with assistance from the group. The data analyst is in charge of collecting data relevant to the execution of the project from appropriate sources. Based on the data collected and after sufficient analysis, conclusions can be drawn from the data and appropriate predictions can be made to facilitate the project execution.

2.2 Timeline

Through the course of completing this project, we do not anticipate any issues within our control that would significantly impact our timely completion. In the case of unforeseen circumstances or malfunctions with the equipment, we will work to communicate these issues adequately to our stakeholders while considering alternative solutions. By following our planned schedule, we believe we will be able to complete our deliveries. Below are the phases for our project duration:

1. Project Conception

This phase began with team formation. Our team consists of Electrical Engineering and Computer Engineering majors in an equal ratio. To select our project, we consulted with various faculty sponsors about their projects and considered factors like our individual skill sets and mutual interests. After the project assignment, we focused on background research and literature review to get a better understanding of the project scope. In order to kick start any work, we had several meetings where we discussed deliverables, role assignment and project expectations. The duration of this phase was from early September 2019 to mid-October 2019.

2. Research & Designing

In consideration of the abstract provided by our project sponsor, we were able to define our project deliverables. We conducted research to identify what we would need and selected the most cost-effective products that met our criteria as well as what development environment would be most suitable to accomplish our objectives. We also worked to design a preliminary design for the physical layout of the embedded system. During this phase, we also developed the presentation for our oral reports and wrote our written reports. The duration was from mid-October till the end of the semester in early December.

2.2 Timeline(Continued)

3. Project Execution

This phase was split because our project has hardware and software components. For the software component, we had to get familiar with Android Studio Integrated Development Environment(IDE) which is the development environment for the Android mobile application. Mobile application development takes several months on average to complete and although the scope of our application is not that big, the functionalities we planned to utilize involve communication with external devices via Bluetooth Application Programming Interface(API). The hardware component involved setting up the Jetson TX2 microcontroller with a computer to flash it and install the Jetpack(which includes the Jetson OS). After setup, programming the camera was vital to ensure it could capture the data we wanted it to. We also designed a physical layout of a typical road intersection with the aim of organizing our various components to show the integration. The duration of this phase was from January 2020 till March 2020.

4. Project Testing

This phase was to include the set-up of the physical components with the road layout we constructed as well as communication between the microcontroller and mobile application and LEDs. The set-up was to have the microcontroller angled at a corner on the edge in a way as to capture incoming road traffic. We have remote-controlled vehicles that were to be used to mimic a typical 4-way road intersection and would trigger the camera when it came into the operating range. The LEDs were also to be lit up to signal bike riders of incoming car vehicles. The mobile application was to receive a signal from the microcontroller and send a push notification to the device. The duration of the phase was March 2020.

2.2 Timeline(Continued)

5. Project Close

This phase was to close out the project and present our work completed in the form of the physical proof of concept, reports and presentations. We spent an ample amount of time making sure we were able to give a detailed account of the functionality of the system to anyone that viewed it. We also ensured to properly close out all documentation such as coding. This phase was in April 2020.

2.3 Gantt Chart

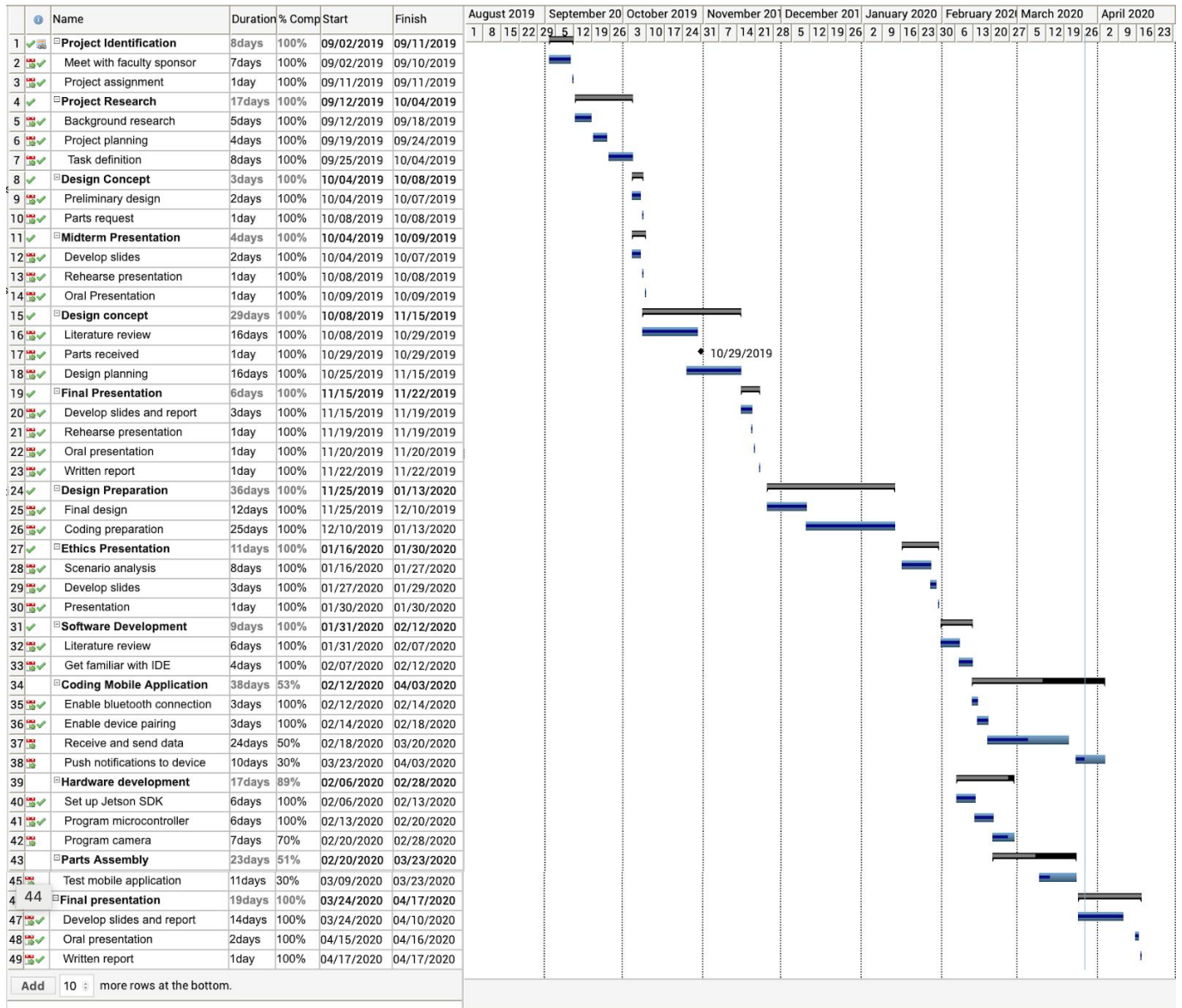


Figure 2.3:Gantt Chart

Section 3 - Literature Review

3.1 Literature Review

To complete this project, we considered several routes to take as the main objective is to reduce bicycle accidents. We read articles that highlighted safety equipment and different ways bicycle riders can stay safe on roads including smart helmets, bicycle LED lights and smart wearables. Even with the mobile application, there are a few options already available on the market. After thorough review of these options as well as discussions with our sponsor, we were able to narrow down the scope of our deliverables.

During our review, we focused on understanding what other alternatives offer so we could identify the gaps that our project can fill. Although a majority of these other options are much more popular on the market, most of them function independently which can impact safety if it stops working. This is a gap we can fill with our embedded system that offers more than one way to alert riders. While the major cost of our project goes towards a one-time installation and future maintenance as needed, other products are a direct cost to the customer which usually sways people away.

For the mobile application, some other options implemented GPS to track riders movement. We considered this but did not choose it because of the scope of our project. Using GPS would not be feasible since our application is not independent and relies on communication with the microcontroller.

Ultimately, we considered the range of effective coverage, less distracting alert systems, appearance and cost-effectiveness when defining the scope of our project. We hope that these factors would appeal to the everyday bike rider to help improve safety on the roads.

Section 4 - Preliminary Design

4.1 Concept Generation

The concept of this project was solely based on identifying how roads could be safer for people for use. This brought about conducting research on how bicycle riders and we discovered the rate at which they are involved in accidents in downtown areas of major cities.

We discovered that since there are object detection and classification mediums provided by machine learning, it could be used to identify a person, car or bicycle on a road. The application of this discovery would only be relevant to our project if there is a range provided. This range comes from the length at which a camera can identify objects with a high percentage of accuracy and a motion sensor which could detect the movement of an object within a certain range. To perform these functions, we looked at getting a microcontroller that would serve an intelligent processing unit to the camera and motion sensor connected (interfaced) to it to create an embedded system. In addition to that, we decided to integrate road lane lights to our concept as an alternate system to provide additional alerts to a bicycle rider and also bring more awareness to the driver on nearby riders.

Thereafter, our final thought process was to feed the information obtained from the camera and motion into a mobile application via bluetooth. The mobile application would be used by the bicycle rider to receive alerts pertaining to dangers that could arise from cars within the specified range of operation.

4.2 Concept Evaluation and Selection

Before we arrived at our concept we compared it to other design concepts based on feasibility, capability and compatibility of the components needed to execute our design. The capability of certain components such as the microcontroller and camera was a very integral part in creating our concept because for our design to work effectively we needed a microcontroller that had a low power consumption rate, bluetooth connectivity, high processing speed and very good for machine learning applications. power efficient. That is why we opted for the NVIDIA Jetson TX2 microcontroller because it had all the qualities we required such as a 7.5W power rating, Bluetooth module, heat sink **. For the object detection and classification, we needed a camera that had a good resolution and consumed low power.

Selecting the components for our design also involved verifying their compatibility and our major compatibility check was with our microcontroller and the camera as well as its bluetooth module connectivity with an Android mobile phone. We chose the bluetooth module over the wifi module for transferring data to the mobile application mainly because our design prototype will require a short range to showcase data transfer capabilities. Although a Wifi module would be ideal for real-life situations, we considered the time and how much it will cost to integrate it into our design. After comparing both using the wifi and bluetooth module, using the wifi module was not feasible for our design

The feasibility of our design was also an integral part of selecting our concept because we had limited time and resources available for the execution of our design.

4.3 Design Constraints and Applicable Codes and Standards

Design Constraints

1. We have to scale down the design for easier mobility and manageability.
2. The range of the camera's scope is limiting.
3. We cannot show the full functionality of the design because it is not a real road with vehicles.

IEEE Codes and Standards

1. **IEEE 829 - 2008: IEEE Standard for Software and System Test Documentation:**

Used as guidelines in order to perform the test of the microcontroller and mobile application

2. **IEEE 802.15.1 - IEEE Standard for Bluetooth:**

Used as guidelines for Bluetooth applications on Short range (10m) wireless technology for cordless mouse, keyboard, and hands-free headset at 2.4 GHz.

3. **IEEE 7.8: IEEE Code of Ethics:**

3) To be honest and fair in stating claims or estimates based on available data

7) To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others.

4. **IEEE 7.6: IEEE Protection of the Public:**

To maintain public safety with the creation of our engineering devices

5. **82079-1-2019 - IEEE/IEC International Standard for Preparation of information for use of products:**

International Standard which provides principles and general requirements for information for the use and preparation of products

4.4 Preliminary Analysis

We aimed to use the customer's needs to evaluate our design for feasibility in terms of the allocated funds and time for our project as well as performing technical analysis on our design. The major demands that must be met by our design include - real time data transfer, weather adaptable road lane lights and having a user friendly application. Real time data transfer is very essential for our design to be efficient because in real life scenarios, accidents occur in split seconds. Ensuring that our NVIDIA Jetson TX2 microcontroller sends the data collected from our components to the application in real time will give riders and drivers a means to avoid being involved in accidents. Having weather adaptable road lane lights is another vital requirement for our design because it is necessary for the lane lights to always be visible regardless of whether it's raining, sunny or dark. This feature will effectively assist drivers in becoming more aware of nearby riders and with that, it makes them drive more carefully. Another major demand that must be met by our design is having a user friendly application. This is an essential feature for the user as the application is being used when the rider is in motion **

Section 5 - Detailed Systems Design

5.1 Equipment Selection and Specifications

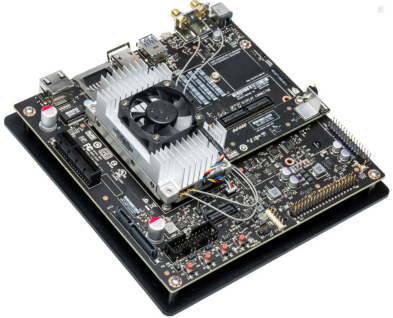
Description	Specifications	Image
Jetson TX2	- Hex-core ARMv8 64-bit CPU complex - Integrated 256-core NVIDIA Pascal GPU - LPDDR4 memory with a 128-bit interface 2.5 Gb/sec per lane for the camera - Bluetooth 4.1 for smarter connectivity	
e-CAM20_CUTX2	2 Megapixel resolution for definition - High Dynamic Range - High-speed 4-lane MIPI CSI-2 interface to connect with the CPU - Low Power Consumption: - Max: 0.87W - Min: 0.67W	
Nexlux Light Emitting Diodes(LED) Strip	- It is waterproof - Low power consumption - Adjustable level of brightness - Bluetooth capability	

Table 5.1: Equipment List

5.2 Final Design

The final design, as shown in Figure 5.2, consists of a 2-D layout of a typical road intersection. The layout includes a car vehicle and a bicycle. The microcontroller is placed on the layout but ideally it will be housed in a secure box on an electrical pole by the intersection at an angle where the camera can capture the incoming road traffic. The LED lights on the bicycle lane would also be present to light up when a vehicle is approaching. A screenshot of the notification alert on a mobile device can be seen, this will be sent after the microcontroller sends the necessary information to do so.

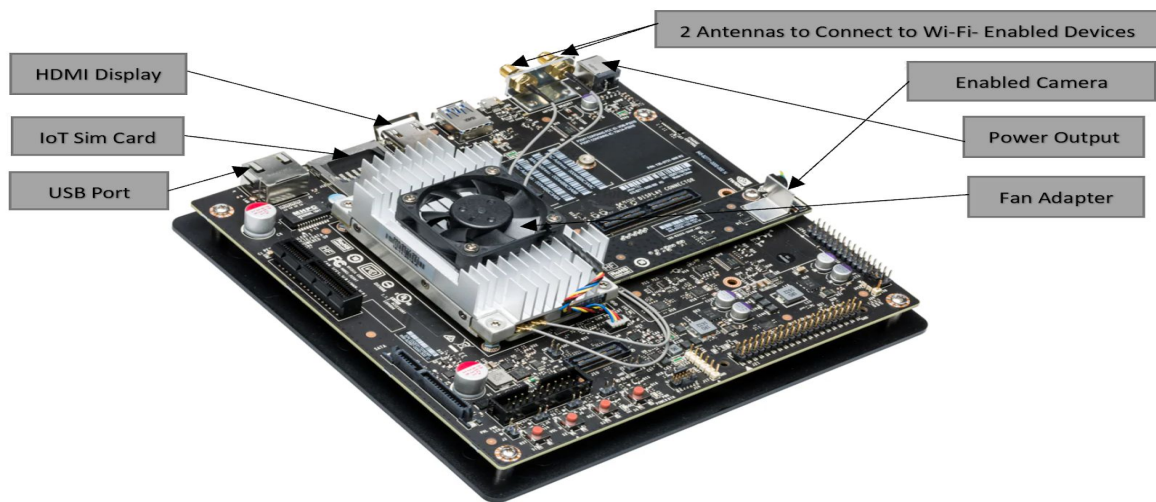


Figure 5.1: Jetson TX2 Microcontroller Front Device

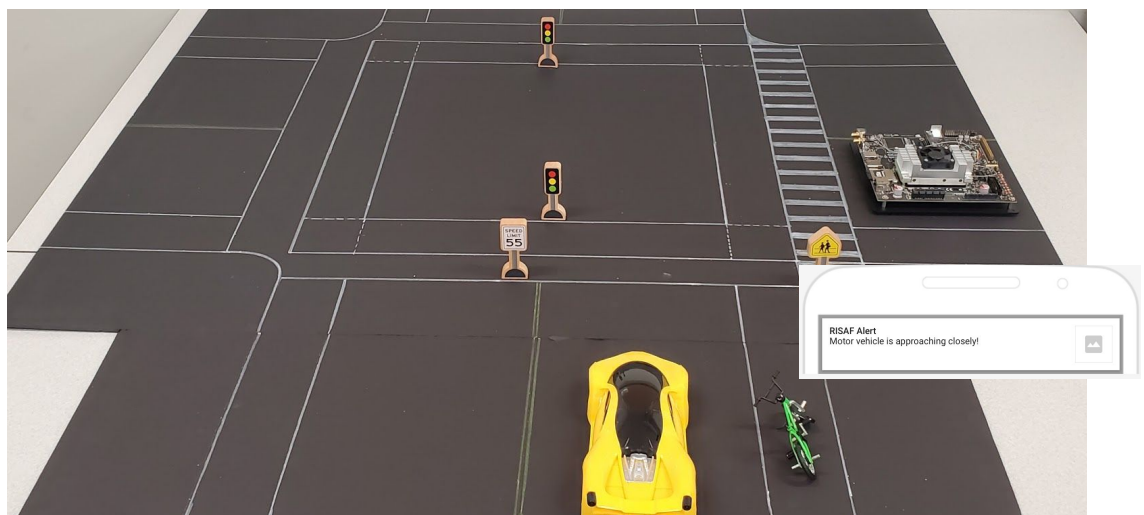


Figure 5.2: Depiction of road intersection with vehicles

5.3 Engineering Analysis and Simulation

Hardware Component

1. Setting up the Jetson TX2 with Jetpack:

NVIDIA JetPack is a comprehensive SDK for Jetson for both developing and deploying AI and computer vision applications. JetPack simplifies installation of the OS and drivers and contains the following components:

- L4T Kernel / BSP
- CUDA Toolkit
- cuDNN
- TensorRT
- OpenCV
- VisionWorks
- Multimedia API's

The Jetson TX2 was flashed by downloading the NVIDIA SDK Manager to a host PC running Ubuntu 18.04 x86_64. To install, the command below was ran on the host terminal:

```
sudo apt install ./sdkmanager-[version].[build#].deb
```

Which was followed by launching it using the command below:

```
Sdkmanager
```

Then, the NVIDIA TX2 was connected using the Micro-USB port to the host PC and was later put into Recovery Mode to begin the installation of the OS and drivers.

5.3 Engineering Analysis and Simulation(Continued)

2. Setting up the Camera for Object Classification and detection:

To do this a project was built from the source, below is a condensed form of the commands to download, build, and install the project:

```
$ sudo apt-get update
$ sudo apt-get install git cmake libpython3-dev python3-numpy
$ git clone --recursive https://github.com/dusty-nv/jetson-inference
$ cd jetson-inference
$ mkdir build
$ cd build
$ cmake ../
$ make -j$(nproc)
$ sudo make install
$ sudo ldconfig
```

3. Running the live detection model

After building the project, the terminal was located in the

jetson-inference/build/aarch64/bin directory to run the live detection program

```
import jetson.inference
import jetson.utils

import argparse
import sys

# parse the command line
parser = argparse.ArgumentParser(description="Locate objects in an image using an object detection DNN.",
                                formatter_class=argparse.RawTextHelpFormatter, epilog=jetson.inference.detection.__doc__)

parser.add_argument("file_in", type=str, help="filename of the input image to process")
parser.add_argument("file_out", type=str, help="filename of the output image to save")
parser.add_argument("--network", type=str, default="ssd-mobilenet-v2", help="pre-trained model to load (see README for list of supported models)")
parser.add_argument("--overlay", type=str, default="box,labels,conf", help="detection overlay flags (e.g. --overlay=box,labels,conf) (default: box,labels,conf)")
parser.add_argument("--threshold", type=float, default=0.5, help="minimum detection threshold to use")

opt = parser.parse_known_args()[0]

# load an image (into shared CPU/GPU memory)
img, width, height = jetson.utils.loadImageRGBA(opt.file_in)

# load the object detection network
net = jetson.inference.detectNet(opt.network, sys.argv, opt.threshold)

# detect objects in the image (with overlay)
detections = net.Detect(img, width, height, opt.overlay)

# print the detections
print("detected {:d} objects in image".format(len(detections)))

for detection in detections:
    print(detection)

# print out timing info
net.PrintProfilerTimes()

# save the output image with the bounding box overlays
jetson.utils.saveImageRGBA(opt.file_out, img, width, height)
```

Figure 5.3: Jetson TX2 Directory Code

5.3 Engineering Analysis and Simulation(Continued)

Afterwards the command below was ran to start the live detection

```
$
```

```
./detectnet-camera.py
```

5.3 Engineering Analysis and Simulation(Continued)

Software Component

The mobile application will receive data from the microcontroller(camera) which will trigger the notification on the mobile device. For the purpose of this project, there are three main components that need to be accomplished in terms of software development. They include:

1. **Set up Bluetooth connection:** The methods shown in the code snippets below show the use of *BluetoothAdapter* class to set up Bluetooth communication with the local Bluetooth module in the smartphone. The other methods included are *bluetoothOn* and *bluetoothOff* to enable and disable bluetooth for device pairing.

```
private void CheckBluetoothState() {
    if(myBluetoothAdapter==null){ //Device does not support bluetooth
        //textView.append("\nBluetooth NOT supported. ");
        return;
    }else{
        if(myBluetoothAdapter.isEnabled()) {
            //textView.append("Bluetooth is enabled");
            //textView.append("\nPaired devices are:\n");
            Set<BluetoothDevice> devices = myBluetoothAdapter.getBondedDevices();// Get a set of currently paired devices and append to 'pairedDevices'
            for (BluetoothDevice device : devices) {
                textView.append("\nDevice: " + device.getName() + ", " + device);
            }
        }else{
            Intent btEnablingIntent = new Intent(BluetoothAdapter.ACTION_REQUEST_ENABLE); //Prompt user to turn on Bluetooth
            startActivityForResult(btEnablingIntent, requestCodeForeEnable);
        }
    }
}

@Override
protected void onActivityResult(int requestCode, int resultCode, @Nullable Intent data) {
    if(requestCode==requestCodeForeEnable)
    {
        if(resultCode==RESULT_OK)
        {
            CheckBluetoothState();
            Toast.makeText(getApplicationContext(), "Bluetooth is Enabled", Toast.LENGTH_LONG).show();
        }else if(resultCode==RESULT_CANCELED)
        {
            Toast.makeText(getApplicationContext(), "Bluetooth Enabling Cancelled", Toast.LENGTH_LONG).show();
        }
    }
}

private void bluetoothONMethod() {
    buttonON.setOnClickListener((v) -> {
        if(myBluetoothAdapter==null)
        {
            Toast.makeText(getApplicationContext(), "Bluetooth does not support device", Toast.LENGTH_LONG).show();
        }else
        {
            if(!myBluetoothAdapter.isEnabled())
            {
                startActivityForResult(btEnablingIntent, requestCodeForeEnable); //turn on bluetooth if disabled
            }
        }
    });
}

private void bluetoothOFFMethod() {
    buttonOFF.setOnClickListener(onClick(v) -> {
        if(myBluetoothAdapter.isEnabled())
        {
            myBluetoothAdapter.disable();
        }
    });
}
```

Figure 5.4: Code snippet showing the enable/disable bluetooth function

5.3 Engineering Analysis and Simulation(Continued)

2. **Receive/Send data between devices:** For this to happen, the connection between the mobile device and microcontroller should be in a separate thread to avoid interference on the user interface thread. In this component, a *BluetoothSocket* is created which is used to transfer data between devices. Like the connection, the data transfer should also be in a separate thread to avoid interference. In the *BluetoothSocket* method, an *InputStream* and *OutputStream* are created to read and write data to the microcontroller respectively. When the program obtains data, it would need to send that data from the data transfer thread back to the main user interface thread and this will be done using a *Handler*. The *Handler* converts the data from a byte array to a string and stores the message.

3. **Push notification on the device:** For this function, a *NotificationManager* class is created which would manage all settings for the notification, including alerts, to the mobile device. To make the notification appear, another method is called *NotificationManagerCompat.notify()* and actions can be added to the notification using the *PendingIntent* method.

5.4 Application of Engineering Codes and Standards

1. **IEEE 829 - 2008: IEEE Standard for Software and System Test Documentation:**

Used as guidelines in order to perform the test of the microcontroller and mobile application

2. **IEEE 802.15.1 - IEEE Standard for Bluetooth:**

Used as guidelines for Bluetooth applications on Short range (10m) wireless technology for cordless mouse, keyboard, and hands-free headset at 2.4 GHz.

3. **IEEE 7.8: IEEE Code of Ethics:**

3) To be honest and fair in stating claims or estimates based on available data

7) To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others.

4. **IEEE 7.6: IEEE Protection of the Public:**

To maintain public safety with the creation of our engineering devices

5. **82079-1-2019 - IEEE/IEC International Standard for Preparation of information for use of products:**

International Standard which provides principles and general requirements for information for the use and preparation of products

5.5 Economic Analysis

PRODUCT	PROS	CONS	COST	REFERENCE
RISAF	1. Vehicle motion and speed detection 2. Dual alert system 3. Embedded system	1. Can only detect speed within 80 feet 2. Alerts may affect an unfamiliar user	\$600	N/A
Beryl Laser Bike Light	1. Bicycle laser light 2. Waterproof	1. Lights might not be visible to motorists in daytime	\$130	https://beryl.cc/shop/laserlight
Revolights	1. Reflective wheel LEDs 2. Weather alerts 3. Turn signals 4. Ride Tracking	1. Affects the balance of wheels 2. Lights might not be visible to motorists in daytime	\$200	http://webcache.googleusercontent.com/search?q=cache:rpphpfj6uoIJ:revolights.com/+&cd=11&hl=en&ct=clnk&gl=us
Livall Bicycle helmet BH60	1. SOS Alert 2. Hands Freephone 3. Smart flashlights for turn signals	1. Inbuilt microphone and Bluetooth speaker can distract the rider	\$120	https://www.livall.com/english/product/overview/id/23.html

Table 5.5: Product Comparison

Section 6 - Results & Discussion

6.1 Summary of Goals And Objectives

For this project, we made it our mission to design an intelligent sensing and alarm system which would be used to help aid in reducing bicycle accidents. With this system in place, we can help assure bicycle riders that they can ride more safely while increasing motorists' awareness of nearby cyclists. As a team, we knew that it was more than just promoting bicycle safety, but we also can help in benefiting the community and society as a whole. Through the increase of safety, it also promotes a healthier community and environment. With the creation of our three deliverables, embedded system, road lane lights, and mobile application, we will be able to accomplish our mission. The embedded system will consist of a Jetson Nvidia TX2 microcontroller, camera and motion sensor. The Jetson Nvidia TX2 will serve as a communication interface for the camera and sensors. The phone mobile application will be designed in Android Studio using the Java programming language. The application will allow the rider to be alerted through sound or vibration. Our road lane light-emitting diodes(LEDs) will be installed on the road between the car and bicycle lanes. They will blink only when the system detects a moving object within the range of 80 feet. Our embedded system should fit on an electrical pole at all road intersections. Our Road lane lights should be weather adaptable and should be visible. Our mobile application should be user-friendly, and also the alert system should not be distracting. After researching the market we saw that typically bicycle safety came in parts but with our system, we wanted to approach safety from the standpoint of preventing the accident before it happens instead of protecting you if it was to happen. With this system, we want to prove that with this system local communities and major cities can adopt this system in order to keep fellow cyclists and members of the community safe.

6.2 Summary of Constraints and Codes Met by Design

RISAF Major Constraints

When thinking about the constraints of our project we had to take into account that not all roads have bike lanes for road lane lights. Also with the creation of our mobile application we know not all bike riders use their mobile device while riding. Lastly, our system cannot detect potential dangers if automobiles or trucks are not within the operating range.

IEEE Codes and Standards

1. **IEEE 829 - 2008: IEEE Standard for Software and System Test Documentation:**

Used as guidelines in order to perform the test of the microcontroller and mobile Application

2. **IEEE 802.15.1 - IEEE Standard for Bluetooth:**

Used as guidelines for Bluetooth applications on Short range (10m) wireless technology for cordless mouse, keyboard, and hands-free headset at 2.4 GHz.

3. **IEEE 7.8: IEEE Code of Ethics:**

3) To be honest and fair in stating claims or estimates based on available data

7) To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others.

4. **IEEE 7.6: IEEE Protection of the Public:**

To maintain public safety with the creation of our engineering devices

5. **82079-1-2019 - IEEE/IEC International Standard for Preparation of information for use of products:**

International Standard which provides principles and general requirements for information for the use and preparation of products.

6.3 Discussion of Results

In order to complete this project, we used the Jetson TXT2 for our embedded system. Our embedded system included both a camera and motion sensors. The information is then recorded from our motion sensor and camera and that information is then sent to our Road Lane Lights, which will only blink when a car is in range of the cyclist. That information is also sent as an alert to our mobile application to help keep our cyclist safe. In order to test this, we created a replica of a typical road intersection, refer to Figure 5.2. With this depiction, we had to scale down our design components. Our camera was able to identify the bicycle and the car. We were able to successfully send messages and pictures captured from our microprocessor to our mobile application. With the outcome of a global crisis we were unable to test our road lane lights, but it was satisfying to see that our embedded system was able to communicate to our mobile application over a bluetooth connection. The results of our system showed that as a team we were able to design an intelligent sensing and alarm system which can be used to help aid in reducing bicycle accidents and deaths. With this system in place, we can help assure bicycle riders that they can ride more safely while increasing their awareness of nearby motorits, through the use of our mobile application and embedded system alone.

Section 7 - Conclusions and Recommendations

7.1 Conclusion and Recommendation

With this project, it can be considered as a non-discretionary project because there are other safety products out there so not implementing ours would not necessarily impact accident rates. Whereas a discretionary project is a project where management has a choice in implementing the project. Our team designed RISAF with the intention to help prevent bicycle accidents and deaths from occurring. With our system, we incorporated factors that put things in place that do not hinder cyclists or drivers from everyday routines. With the implementation of our embedded system which is the brain of the system that processes and delivers the information of the things occurring within range of the motion sensor and camera. The rest of the body, road lane light and mobile application, are extensions that enable the cyclist and driver to be aware of each other, whether they see them or not. The implementation of our system will greatly impact the safety culture amongst both bicycle riders and car drivers.

Additional features can be configured with more specifications for the system. Those features can include but is not limited to; mobile application for iphone users, Mobile application for iphone users, using a wifi module for larger area connectivity and a camera with both medium and long shots

References

1. NHTSA's National Center for Statistics and Analysis, "Bicyclists and Other Cyclists", March 2015, <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812382>
2. E-CON Systems, "e-CAM20_CUTX2 – 2MP HDR Jetson TX2/TX1 Camera Board", <https://www.e-consystems.com/2MP-HDR-Jetson-TX2-TX1-Camera-Board.asp>
3. Leopard Imaging, "LI-IMX185-MIPI-M12", <https://leopardimaging.com/product/li-imx185-mipi-m12/>
4. C. Komanoff et al, "Environmental Benefits of Bicycling and Walking in the United States", Transportation Research Record 1405, <http://onlinepubs.trb.org/Onlinepubs/trr/1993/1405/1405-002.pdf>
5. C. C.O. Reynolds et al, "The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature" DOI: 10.1186/1476-069X-8-47, October 2009
6. The State of Queensland (Department of Transport and Main Roads)" Cycling benefits" June 2018, <https://www.tmr.qld.gov.au/Travel-and-transport/Cycling/Benefits.aspx>
7. Z. Bielak, "From Pedal to People: The Social Effects of Biking", ResearchGate, DOI: 10.13140/RG.2.2.30923.18721, June 2015
8. M. Anderson, "No, Protected Bike Lanes Are Probably Not Too Expensive For Your City To Build (Chart)" March 2014, <http://peopleforbikes.org/blog/no-protected-bike-lanes-are-probably-not-too-expensive-for-your-city-to-build-chart/>